

Impact of symptom-guided, progressive cardiac rehabilitation after left ventricular assist device implantation

Katelyn D. Brown, MS^a, Heath W. Shirkey, BSN^a, Tiffany Shock, BS^a, Katherine Thornton, PA-C, MSPAS^b, Aldo E. Rafael-Yarihuaman, MD^b, and Amarinder Bindra, MD^c

^aDepartment of Cardiac Rehabilitation, Baylor Scott and White Heart and Vascular Hospital, Dallas, Texas; ^bDepartment of Cardiothoracic Surgery, Baylor University Medical Center, Dallas, Texas; ^cCenter for Advanced Heart and Lung Disease, Baylor University Medical Center, Dallas, Texas

ABSTRACT

A 29-year-old woman with a left ventricular assist device (LVAD) completed a progressive, symptom-limited cardiac rehabilitation program consisting of boxing, weight-lifting, and aerobic exercise, where she improved her exercise capacity by 2.7 metabolic equivalents ($P < 0.001$) and demonstrated significant myocardial recovery, allowing for successful LVAD explant 9 months after implantation.

KEYWORDS Cardiac rehabilitation; exercise; explant; heart failure; LVAD; resistance training

Although the benefits of cardiac rehabilitation have been investigated and established in a variety of acute and chronic cardiovascular diseases, the role of cardiac rehabilitation in improving functional myocardial recovery for patients with advanced heart failure treated with left ventricular assist devices (LVAD) has not been widely investigated.^{1–3}

CASE DESCRIPTION

A 29-year-old woman with a known congenital defect of the aortic valve leaflet suffered an acute myocardial infarction at work requiring venoarterial extracorporeal membrane oxygenation support, emergent LVAD implantation, atrial-septal defect repair, left ventricular and left atrial thrombectomy, and aortic valve replacement, after which she enrolled in cardiac rehabilitation. Upon admission, she was unable to tolerate traditional baseline exercise tolerance testing due to persistent symptoms and severe deconditioning. In lieu of this, a progressive, individualized treatment plan was initiated to help her regain myocardial function and quality of life.

She was able to tolerate symptom-limited, light-intensity resistance exercises (~2 metabolic equivalents [METs]), including light hand-weights, resistance bands, and machine weights, up to 20 minutes with frequent rest breaks and a rate of perceived exertion (RPE CR-10) of 6, as well as walking on a padded track (one-third mile) and light-intensity (3–4 METs) seated bilateral upper-extremity boxing. Her resting and exercising electrocardiogram was significant for sinus tachycardia with frequent premature ventricular complexes, and she subjectively reported fatigue, shortness of breath, lightheadedness, and dizziness during rest and exercise. She experienced several low-flow events with accompanying hypotension (mean arterial pressure ~52), nausea, and vomiting, which resolved with fluids, supine rest, and ultimately adjustment of medication. As she progressed through the cardiac rehabilitation program, she was able to complete one-third mile at a jogging pace without rest breaks, perform standing boxing exercises, and begin more dynamic, moderate-intensity resistance exercises, such as battle ropes and kettlebell exercises (*Figure 1*).

After completing 36 sessions of cardiac rehabilitation, her left ventricular ejection fraction recovered from 13% to

Corresponding author: Katelyn D. Brown, MS, Department of Cardiac Rehabilitation, Baylor Scott and White Heart and Vascular Hospital, 411 N. Washington Ave., Ste. 3100, Dallas, TX 75246 (e-mail: Katelyn.brown@bswhealth.org)

The authors report no conflicts of interest. The patient has given permission for this case report to be published.

Received February 2, 2021; Revised April 9, 2021; Accepted April 12, 2021.



Figure 1. LVAD recipient performing high-intensity resistance exercise in outpatient cardiac rehabilitation.

55%, she demonstrated normal filling pressures and an adequate cardiac index on low LVAD revolutions per minute, and she subsequently underwent successful LVAD explantation in September 2019. The LVAD was explanted via thoracotomy and redo median sternotomy; a redo aortic valve replacement was performed and the ventriculotomy was closed using a custom-made synthetic plug. Following surgery, her left ventricular function remained stable at 50% without an LVAD and she was discharged home on postoperative day 14, where she completed cardiac rehabilitation again with few subjective complaints. No post-cardiac rehabilitation measures were performed due to closures resulting from COVID-19; however, she was able to return to her level of function prior to LVAD after successfully completing 11 weeks of cardiac rehabilitation. In addition to her subjective well-being, she demonstrated impressive functional exercise capacity (METs) improvement and tolerance for exercise from her first bout of cardiac rehabilitation (34 sessions, mean = 3.559, standard deviation = 1.186 METs) to the beginning of her second bout (33 sessions, mean = 6.315, standard deviation = 2.416; $P < 0.001$, Student's t test).

DISCUSSION

LVAD implantation is an effective treatment for severe or end-stage heart failure, traditionally serving as a bridge to heart transplant or destination therapy for medical management. In <2% of cases, predominantly in younger patients with nonischemic cardiomyopathies, evidence of myocardial recovery encourages weaning of support and explantation of the device, allowing for an increasingly recognized category of “bridge to recovery.”^{1–3} Although LVAD implantation can improve survival, extensive risks associated with LVAD support and the potential for a significantly improved quality of life compared even to those who are subsequently transplanted support the initiative for aggressive rehabilitation and medical management in hopes of recovery and explantation.^{4–6}

In the traditional outpatient cardiac rehabilitation setting, light to moderate aerobic activity is typically prescribed for patients with LVADs, such as treadmill walking or cycle ergometer training, and strength training is modestly prescribed, if not avoided, with hand weights, elastic bands, and lower-extremity machine weights.^{7,8} After LVAD implantation, this patient hoped to return to her previous recreational activities; therefore, a progressive, symptom-limited training program was designed including boxing, resistance exercise, and track walking. By utilizing the Keep Your Move in the Tube[®] method for active living following sternotomy, the patient was able to perform upper-extremity resistance exercises based solely on tolerance and symptomology rather than arbitrary weight and time restrictions.⁹

After explant, she adhered to the same recommendations, which allowed her to return quickly and safely to her athletic endeavors (water skiing, etc.) and subsequently graduate from cardiac rehabilitation with no related readmissions to date. Although post-explant cardiac rehabilitation outcomes were not performed due to COVID-19 closure of outpatient cardiac rehabilitation centers, her average maximum exercise capacity increased by 2.7 METs ($P < 0.001$) from her first cardiac rehabilitation session after LVAD implantation to her first cardiac rehabilitation session after LVAD explant, which is associated with significant decreases in all-cause and cardiovascular morbidity and mortality.¹⁰

In conclusion, this case supports the need for aggressive, symptom-limited rehabilitation in conjunction with medical management for patients with durable mechanical circulatory support devices. This 29-year-old LVAD recipient demonstrated significant myocardial recovery after an acute myocardial infarction through progressive, individualized aerobic and strength training and was able to demonstrate tremendous recovery in subjective and objective measures of health and fitness <1 year from the primary event. Although LVAD explant is rare, the potential for functional recovery as demonstrated in this case supports a progressive rehabilitative program consisting of symptom-limited resistance and endurance training for the rehabilitation of LVAD recipients despite the implant strategy.

1. Dandel M, Weng Y, Siniawski H, et al. Pre-explant stability of unloading-promoted cardiac improvement predicts outcome after weaning from ventricular assist devices. *Circulation* 2012;126(11_suppl_1):S9–S19. doi:10.1161/CIRCULATIONAHA.111.084640.
2. Kirklin JK, Naftel DC, Kormos RL et al. Fifth INTERMACS annual report: risk factor analysis from more than 6,000 mechanical circulatory support patients. *J Heart Lung Transplant*. 2013;32(2):141–156. doi:10.1016/j.healun.2012.12.004.
3. Selzman CH, Madden JL, Healy AH, et al. Bridge to removal: a paradigm shift for left ventricular assist device therapy. *Ann Thorac Surg*. 2015;99(1):360–367. doi:10.1016/j.athoracsur.2014.07.061.
4. Kirklin JK, Naftel DC, Pagani FD, et al. Seventh INTERMACS annual report: 15,000 patients and counting. *J Heart Lung Transplant*. 2015;34(12):1495–1504. doi:10.1016/j.healun.2015.10.003.

5. Maciver J, Ross HJ. Quality of life and left ventricular assist device support. *Circulation*. 2012;126(7):866–874. doi:[10.1161/CIRCULATIONAHA.111.040279](https://doi.org/10.1161/CIRCULATIONAHA.111.040279).
6. Stewart GC, Brooks K, Pratibhu PP, et al. Thresholds of physical activity and life expectancy for patients considering destination ventricular assist devices. *J Heart Lung Transplant*. 2009;28(9):863–869. doi:[10.1016/j.healun.2009.05.016](https://doi.org/10.1016/j.healun.2009.05.016).
7. Kerrigan DJ, Williams CT, Ehrman JK, et al. Cardiac rehabilitation improves functional capacity and patient-reported health status in patients with continuous-flow left ventricular assist devices: the Rehab-VAD randomized controlled trial. *JACC Heart Fail*. 2014;2(6):653–659. doi:[10.1016/j.jchf.2014.06.011](https://doi.org/10.1016/j.jchf.2014.06.011).
8. Marko C, Xhelili E, Lackner T, Zimpfer D, Schima H, Moscato F. Exercise performance during the first two years after left ventricular assist device implantation. *Asaio J*. 2017;63(4):408–413. doi:[10.1097/MAT.0000000000000569](https://doi.org/10.1097/MAT.0000000000000569).
9. Adams J, Lotshaw A, Exum E, et al. An alternative approach to prescribing sternal precautions after median sternotomy, “Keep Your Move in the Tube.” *Baylor Univ Med Center Proc*. 2016;29(1):97–100. doi:[10.1080/08998280.2016.11929379](https://doi.org/10.1080/08998280.2016.11929379).
10. Kodama S, Saito K, Tanaka S, et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. *JAMA*. 2009;301(19):2024–2035. doi:[10.1001/jama.2009.681](https://doi.org/10.1001/jama.2009.681).

Avocations



“Texas rodeo.” Photo copyright © Rolando M. Solis, MD. Dr. Solis is co-medical director of the Cardiopulmonary Rehabilitation Program of the Baylor Scott & White The Heart Hospital – Plano. Prior to his current position, he practiced interventional cardiology at Baylor University Medical Center in Dallas, Baylor Medical Center at Garland, and Baylor Scott & White The Heart Hospital – Plano for over four decades. (e-mail: rmsolis@mac.com).